Resource Department

Ecology

Terry Hazen

tchazen@lbl.gov
(510)486-6223

SCIENTIFIC FOCUS AREAS

The Ecology Department (ED) intends to maintain the highest quality and highest visibility for its research and development in four areas:

- Hydroecological engineering advanced decision support
- Molecular microbial ecology
- Real-time assessment of bioavailability and biokinetics
- Bioremediation and natural attenuation

These four R&D areas are largely integrated, but contain some domains that are not inclusive. These four areas are considered ED's core competencies.

HYDROECOLOGICAL ENGINEERING ADVANCED DECISION SUPPORT (HEADS)

The HEADS research focus area has established a strong track record in the rapidly growing, new subject area of Ecological Engineering. The term "hydroecological engineering" signifies the group's concentration on water resources and wastewater engineering. Recognizing the growth in the field of environmental informatics and the application of computer-based models in the development of decision support systems, the group is active in this niche area. Interest in decision support interfaces well with the group's expertise in the deployment of real-time flow and water quality sensors, rapid laboratory assessment techniques, and mathematical models to develop an early warning system for contaminant management and containment.

MOLECULAR MICROBIAL ECOLOGY (MME)

Understanding microbial interactions is key to the study of global warming, biodegradation of harmful compounds, and the exploration of complex microbial communities in their natural environment. The DOE has placed an increased emphasis on the role microbes play in modifying their environment and their impact on energy security. The MME group has responded to these needs by aggressively seeking out new projects and expanding its staff to develop new core capabilities. One of the key challenges has been to harness the explosion of microbial DNA sequence information to accurately measure the microbial dynamics in extreme environments. Since less than one percent of the microbial species can be cultured from these environments, our knowledge of what these organisms may be doing is limited to where they are observed and the similarity of their genomes to studied organisms. By understanding the ecological structure of microbial communities and the fine-scale dynamics resulting from subtle perturbations, it may be possible to identify novel functional pathways and use the diverse microbial capabilities to assist in key DOE missions. The molecular tools being developed in the ESD's Center for Environmental Biotechnology will position us to be leaders in this area.

REAL-TIME ASSESSMENT OF BIOAVAILABILITY AND BIOKINETICS (RABB)

Interactions between environmental pollutants and ecological receptors begin when the pollutants become available to the target sites of a live ecological receptor. The ability to characterize the dynamics of the bioavailability of pollutants, their transformation kinetics, and the subsequent ecological response is a keystone to advancing the science in relevant DOE areas, including biogeochemistry, bioremediation, and

exposure and risk assessment. Since 1999, the RABB research group at ED has pioneered the development and application of several cutting-edge technologies, such as synchrotron radiation-based spectromicroscopy, *in vitro* human gastrointestinal mimetic reactors, and *in vivo* mouse protocols that allow for the real-time assessment of bioavailability and biokinetics of environmental pollutants. The RABB group intends to establish this capability further by seeking out new projects and new collaborators, as well as expanding our staff, to position us as leaders in the areas of biological and environmental sciences.

BIOREMEDIATION AND NATURAL ATTENUATION

Bioremediation and natural attenuation have been rapidly growing areas of science over the past decade. The acceptance of natural attenuation as a solution for cleaning up contaminated sites, and DOE's recognition that they will have long-term stewardship issues that they must address at the most contaminated sites, has greatly increased the urgency for basic and applied research related to microbial ecology and biogeochemistry. This type of research is truly enabling for natural attenuation, since characterization, predictions, and verification monitoring require a strong scientific basis. Natural attenuation is viewed as the best solution for cleaning up many waste sites and will save billions of dollars in cleanup costs.

ED scientists and engineers are recognized leaders in the field of bioremediation and natural attenuation. The Center for Environmental Biotechnology provides the primary facilities used by ED, including state-of-the-art equipment for microbiology and environmental engineering. ED investigators have extensive experience in both water treatment and bioremediation, especially co-metabolic biodegradation and the treatment of inhibitory compounds. In addition to basic research, ED investigators have been involved in various aspects of more than 100 field demonstrations and deployments, and have five patents in this area that are licensed to more than 30 companies. The types of contaminants in which ED investigators have expertise include chlorinated solvents, petroleum hydrocarbons, polynuclear aromatic hydrocarbons, ketones, methyl tert-butyl ether (MTBE), TNT, inorganic nitrogen (NO_3, NH_4), tritium, plutonium, neptunium, chromium, and uranium. The Bioremediation and Natural Attenuation area has both basic research and field application foci for the ED. The basic research foci are co-metabolism, biotreatability, biotransformation kinetics, and modeling of biogeochemical processes. Field-application foci are co-metabolic techniques, biogeochemical assessment techniques, and modeling of attenuation and environmental fate.

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